MA 28: Magnetic Thin Films III

Time: Thursday 14:30–17:30 Location: H 1012

MA 28.1 Thu 14:30 H 1012

Structural and magnetic properties Nickel/rubrene(peroxide) bilayers — •Wen Li[1], Felix Springer[2], Manfred Albrecht[1], Dietrich R.T. Zahn[1], and Georgeta Salvan[1] — [1]Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]University of Konstanz, Department of Physics,D-78457 Konstanz,Germany

Bilayers of nickel/rubrene were obtained by sequential deposition of rubrene and Ni onto Si(111) substrate under ultra-high vacuum conditions. Ex situ AFM studies show that the growth mode of Ni is significantly influenced by the thickness of the underlying rubrene layer. When deposited onto a 14nm rubrene layer Ni forms large islands, hundreds of nanometers in lateral dimension, with large voids between them. On thicker rubrene layers the Ni islands are much smaller forming an almost continuous film.

The hysteresis curves recorded ex situ by magneto-optical Kerr effect (MOKE) measurements in polar geometry show that the magnetic properties change according to the different growth modes. The hysteresis behavior of Ni(7nm)/rubrene peroxide(14nm) shows a combination of ferromagnetic and superparamagnetic behaviour. When the thickness of the rubrene underlayer increases the system behaves ferromagnetically.

The spectroscopic MOKE measurements show that the signal intensity and the energetic position of the spectral features are strongly influenced by the rubrene thickness. Compared to the single Ni(7nm) layer deposited on Si, the MOKE signal of bilayers can be enhanced by about a factor of three.

MA 28.2 Thu 14:45 H 1012

An ab-initio description of the magnetic shape anisotropy — •Sven Bornemann and Hubert Ebert — Department Chemie und Biochemie, LMU München, Germany

For magnetic transition metal systems with reduced dimensionality and low symmetry the shape anisotropy becomes a significant contribution to the magnetic anisotropy. In fact, it can reach the same order of magnitude as the spin-orbit induced anisotropy. So far, the shape anisotropy has been always treated as a classical interaction between magnetic dipoles while the spin-orbit anisotropy has been determined by relativistic band structure calculations. It is uncertain, however, whether such an inconsistent treatment of the two anisotropy contributions is still valid for low dimensional nano structures such as magnetic thin films, wires or clusters where the magnetic easy axis can depend strongly on the interplay between these two contributions.

As an alternative to the standard approach an ab-initio description of the shape anisotropy has been developed. This is achived by including the Breit interaction, which is the natural cause of the shape anisotropy, in the Dirac-equation set up within the framework of spin density functional theory. We have implemented this approach using the fully relativistic KKR band structure scheme. We will present the details of our implementation and show first results for the shape anisotropy of thin films in comparison with the classical treatment.

MA 28.3 Thu 15:00 H 1012

Magnetism of 3*d*-transition metals on Rh(100) — •Ali Al-Zubi, Gustav Bihlmayer, and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

Motivated by recent publications [1,2] reporting on unexpected magnetic properties of ultrathin magnetic films on 4*d* and 5*d* metal substrates, we employ DFT in conjunction with the full-potential linearized augmented plane wave (FLAPW) method implemented in the `FLEUR` code to study systematically the magnetic properties of the 3*d* transition-metal (V, Cr, Mn, Fe, Co and Ni) monolayers on the Rh(100) surface. Including relaxations, we predict a ferromagnetic (FM) ground state for V, Co and Ni, while Cr, Mn and Fe favor the $c(2\times2)$ antiferromagnetic (AFM) state. The unexpected $c(2\times2)$ AFM for Fe encouraged more detailed investigations of this system such as e.g. the row-wise AFM $p(1\times2)$ order. The role of the hybridization between the monolayers and the Rh substrate is analyzed by comparing the results to those of 3*d* monolayers on Ag(100) and Pd(100).

[1] P. Ferriani *et al.*, Phys. Rev. Lett. **99**, 187203 ('07)
[2] P. Ferriani *et al.*, Phys. Rev. B **72**, 024452 ('05)

MA 28.4 Thu 15:15 H 1012

Iron and its native oxide: From chemical structure to magnetic ordering — •Sebastien Couet[1], Kai Schlage[1], Karel Saksl[2], and Ralf Röhslberger[1] — [1]Hamburger Synchrotron Strahlungslabor (HASYLAB) at Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, 22607 Hamburg — [2]IMR, Slovak Academy of Sciences Watsonova, 4704353 Kosice, Slovak republic

It has been demonstrated recently that a strong non collinear magnetic coupling appears between metallic iron layers separated by nanolayer of native iron oxide[1]. Although the microscopic coupling mechanism is not fully understood, theoretical models suggest that it is due to an antiferromagnetic (AFM) order of the oxide layer. As the different oxide phases of iron appear in different magnetic states, it is crucial to resolve the chemical structure of the native oxide to understand the underlying magnetic properties. We therefore investigated the oxidation process in-situ by X-ray absorption spectroscopy. This technique allows us to get quantitative information about the chemistry and the local order in the layer. The study shows that the native oxide at saturation is composed of a mixture of iron oxide phases with a predominance of Fe^{3+} iron species. Upon coverage by a thin iron layer, the oxide is completely reduced and only an FeO like phase remains. This quantitative study shows that it is possible to control the thickness and structure of those native oxide and open the possibility to tailor the magnetic coupling of the system.

[1] Th. Diederich, S. Couet, R. Röhlsberger, Phys. Rev. B **76**, 54401 (2007).

MA 28.5 Thu 15:30 H 1012

Investigation of ferromagnetism in oxygen deficient Hafnium oxide thin films — •Erwin Hildebrandt[1], Jose Kurian[1], Yoshiharu Krockenberger[1], Andreas Suter[2], Fabrice Wilhelm[3], Andrei Rogalev[3], and Lambert Alff[1] — [1]Institut für Materialwissenschaft, TU Darmstadt — [2]PSI, Villingen, Schweiz — [3]ESRF, Grenoble, Frankreich

Oxygen deficient thin films of hafnium oxide were grown on single crystal *r*-cut and *c*-cut sapphire by reactive molecular beam epitaxy. RF-activated oxygen was used for the in situ oxidation of hafnium oxide thin films. Oxidation conditions were varied substantially in order to create oxygen deficiency in hafnium oxide films intentionally. The films were characterized by x-ray and magnetic measurements. X-ray diffraction studies show an increase in lattice parameter with increasing oxygen deficiency. Oxygen deficient hafnium oxide thin films also showed a decreasing bandgap with increase in oxygen deficiency. The magnetisation studies carried out with SQUID did not show any sign of ferromagnetism in the whole oxygen deficiency range. X-ray magnetic circular dichroism measurements also confirmed the absence of ferromagnetism in oxygen deficient hafnium oxide thin films.

MA 28.6 Thu 15:45 H 1012

Preparation and magnetization reversal of exchange bias structured thin films — •Christine Hamann, Jeffrey McCord, Ingolf Mönch, Rainer Kaltofen, Thomas Gemming, Rudolf Schäfer, and Ludwig Schultz — Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstr. 20, 01069 Dresden

Magnetically patterned thin films of NiFe/IrMn/Ta – NiFe/$IrMnO_x$ with laterally modulated unidirectional anisotropy were prepared by local oxidation of the antiferromagnetic IrMn layer. Varying the lateral dimensions and orientation with respect to the anisotropy modulation, the films exhibit different magnetization reversal behaviors. While stripes aligned parallel to the unidirectional anisotropy direction display a spin valve-like two step hysteresis loop, perpendicular orientation lead to a single step shifted hysteresis loop. Magnetic domain observation reveals separate switching of the stripes for the parallel alignment and simultaneous reversal for the perpendicular orientation. By decreasing the lateral dimensions, quasi-domain states have been observed. The presented magnetic data of the exchange biased-pattered films show that we did succeed in creating an alternative method for the preparation of materials with new hybrid properties.

MA 28.7 Thu 16:00 H 1012

Thermal stability of GMR stack systems: Parameter variation of the artificial antiferromagnet — •Matthias Hawraneck[1,2], Wolfgang Raberg[1], Jürgen Zimmer[1], Klemens

Prügl[1], Thomas Bever[1], and Lambert Alff[2] — [1]Infineon Technologies AG, Am Campeon 1-12, 85579 Neubiberg — [2]Institut für Materialwissenschaft, TU Darmstadt, Petersenstr. 23, 64287 Darmstadt

After the discovery of the GMR effect in 1988 by Peter Grünberg and Albert Fert, this effect has gained a huge interest, because of its application potential. A very important attribute of GMR stacks system used in applications, e.g. read heads or automotive sensors, is their thermal stability, due to the lifetime and the temperature profiles in these applications. In high volume production of thin layers, like in GMR stacks, a certain variation of the thicknesses and the compositions of different layers have to be anticipated. Besides the resulting differences in performance, the influence of these variations on the stability is very important. Therefore we focus in our studies on the influence of process variations of the artificial antiferromagnet on the thermal stability.

MA 28.8 Thu 16:15 H 1012

AMR-induced microwave photoresistance and photovoltage in ferromagnetic films — •Nikolai Mecking[1,2], Yongsheng Gui[1], and Can-Ming Hu[1] — [1]Dep. of Physics, University of Manitoba, Winnipeg, Canada — [2]IAP, Uni Hamburg, Jungiusstr. 11, 20355 Hamburg

We have investigated the microwave photoresistance (PR) and photovoltage (PV) of photolithographically stripe shaped ferromagnetic $Ni_{80}Fe_{20}$-films [1-3]. Along these we find maximal AMR with parallel magnetization M and minimal AMR with perpendicular M. However, excited to precess M shifts and the AMR decreases in the parallel case (negative PR) and increases in the perpendicular case (positive PR) [1]. Additionally M precession causes an AMR oscillation that partially rectifies the microwave current I (PV). M can be excited through FMR [1], standing exchange spin waves [2] or magnetostatic modes [3]. These are very sensitively detected during magnetic field sweeps and show a linear combination of dispersive and Lorentz line shape whose ratio is determined by the phase difference between M and I [1]. So, while the PR shows only Lorentz line shape, the PV gives us an insight into the phase of M. Moreover, due to the ferromagnetic susceptibility anisotropy we can distinguish the PV portions arising from the different spatial components of the exciting microwave magnetic field and resolve their phase [1] what is interesting for magnetic field sensing. We acknowledge support from BMBF 01BM461, SFB 508 and the DAAD.

[1] N. Mecking, Y.S. Gui, and C.-M. Hu, ArXiv/cond-mat 0710.1974.
[2] Y.S. Gui, N. Mecking *et al.*, PRL **98**, 107602 (2007).
[3] Y.S. Gui, N. Mecking, and C.-M. Hu, PRL **98**, 217603 (2007).

MA 28.9 Thu 16:30 H 1012

Transition from TMR to AMR in ultrathin magnetic films — •Alexander von Schmidsfeld, Stephen Krzyk, Mathias Kläui, and Ulrich Rüdiger — Fachbereich Physik, Universität Konstanz, 78457 Konstanz

We report on the transition from tunneling magnetoresistance (TMR) to anisotropic magnetoresistance (AMR) in ultrathin magnetic films grown on insulating substrates at low temperature. In situ magnetotransport measurements were carried out in a UHV MBE chamber during film growth. The magnetotransport characteristics changed from a TMR regime towards AMR with increasing film thickness. This transition occurs at thicknesses of several monolayers, indicating island growth. By further increasing the fim thickness above 10 ML, AMR dominates, indicating a transition from islands to a continuous film. This transition zone around the percolation threshold was investigated with high thickness resolution for different materials.

MA 28.10 Thu 16:45 H 1012

A new magnetic octupole setup for in situ investigations on magnetic nanostructures — •Norman Wilken, Stefan Polei, Nagamony Ponpandian, Armin Kleibert, and Karl-Heinz Meiwes-Broer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Magnetic clusters and nanostructures are highly interesting candidates for many applications as ,e.g., magnetic mass storage devices. Thus, strong efforts have been undertaken in the past in order to prepare and study the properties of nanosized magnets. In particular techniques based on magneto-optics in the visible as well as in the soft x-ray regime [for instance the resonant x-ray magnetic circular dichroism (XMCD)] have been successfully applied in many investigations, see e.g. Ref.1. In this contribution we will present a new experimental setup enabling for sophisticated studies on magnetic nanostructures. The main part of the setup is a magnetic octupole consisting of eight resistive magnets, equally spaced on the corners of a cube. This configuration provides an omnidirectional field vector with a magnitude of up to 1 Tesla. A sample preparation chamber as well as the arc cluster ion source (ACIS) being attached to the magnet chamber allow for full in situ preparation and investigation on a broad variety of magnetic nanostructures [2]. Recent experiments on magnetic thin film samples carried out at BESSY reveal the capabilities for transmission, reflection and absorption experiments in the soft x-ray regime.

[1] J. Bansmann et al., Surf. Sci. Reports **56**, 189 (2005)
[2] A. Kleibert et al., J. Appl. Phys. **101**, 114318 (2007)

MA 28.11 Thu 17:00 H 1012

Scanning Tunneling Microscopy and Spectroscopy Measurements on a $(La_{1-0.375}Pr_{0.375})_{0.7}Ca_{0.3}MnO_3$ Thin Film — •Christin Kalkert, Lakshmana Sudheendra, Vasily Moshnyaga, Bernd Damaschke, and Konrad Samwer — I.Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

One of the main goals of manganite physics is to reach an understanding of the metal-insulator transition and associated colossal magnetoresistance effect (CMR). Scanning tunneling microscopy (STM) and spectroscopy (STS) measurements may play an important role in explaining these phenomena since they resolve the spatial distribution and evolution of electronic states across the transition temperature.We have studied a $(La_{1-0.375}Pr_{0.375})_{0.7}Ca_{0.3}MnO_3$ thin film epitaxially grown by metalorganic aerosol deposition on MgO substrate. STS measurements show a homogeneous insulating behavior at room temperature and high resolution STM measurements lead to the assumption that we are dealing with a charge ordered state. STM and STS measurements at temperatures below T_C yield an electronically phase-separated state with an insulating state showing the same conductivity as the homogeneous high temperature state coexisting with a metallic state. Close to T_C we have also observed phase separation. Here we see the high temperature state but also a phase with an intermediate conductivity. This work is supported by DGF via SFB 602 TPA2 and the Leibniz program.

MA 28.12 Thu 17:15 H 1012

Skyrmion states in confined condensed matter systems with intrinsic or surface-induced chirality — •Andrei A. Leonov[1,2], Igor E. Dragunov[2], Christian Pfleiderer[3], Ulrich K. Rössler[1], and Alexei N. Bogdanov[1,2] — [1]IFW Dresden — [2]Donetsk Institute for Physics and Technology — [3]Physik Department E21, TU München

Chiral interactions stabilize smooth "Skyrmion" textures in ordered condensed matter systems. Unconventional Skyrmion states may be observable in magnetic nanostructures, where the chiral Dzyaloshinskii-Moriya exchange arises owing to reduced dimensionality and modified electronic properties of surfaces [1]. Similar surface effects exist also in ferroelectric layers and in confined liquid crystals. We develop a phenomenological theory for modulated and localized states in films of noncentrosymmetric ferromagnets and chiral liquid crystals with strong surface anisotropy or anchoring. Skyrmions with convex shape exist as localized and topologically stable excitations in collinearly ordered states of such films. The solutions for these two-dimensional "Baby-Skyrmions" are related to spherulitic domains in chiral nematic films. The theory describes Skyrmions with variable shapes. This variety is determined by the nature of the chiral coupling, which may arise due to broken inversion symmetry at surfaces or noncentrosymmetric crystal structures as in the chiral magnet MnSi [2].

[1] C. Pfleiderer, U.K. Rößler, Nature 447 (2007) 157; [2] U.K. Rößler, A. N. Bogdanov, C. Pfleiderer, Nature 442 (2006) 797.